500), and/or microchannel reboiler (**130, 130**B, **600, 700**) may be controlled by employing partially boiling heat exchange fluids in the heat exchange channels (**126, 127, 136, 137, 350, 360, 470, 475, 540, 550, 630, 640, 730, 740**) adjacent to the microchannel distillation sections, microchannel condenser and/or microchannel reboiler. The heat exchange channels may be divided into separate heat exchange channel zones. The heat exchange channel zones within each heat exchange channel may be formed by dividing the heat exchange channel into separate heat exchange channel zones using passive structures (i.e., obstructions), orifices at the inlet and outlet of each heat exchange channel zone, and/or by using mechanisms that control the flow rate and/or pressure of the heat exchange fluid in each of the heat exchange channel zones. Each heat exchange channel may be divided into any number of separate heat exchange channel zones, for example, from 2 to about 2000 heat exchange channel zones, and in one embodiment from 2 to about 200 heat exchange channel zones. Each of the heat exchange channel zones may provide heat exchange with any number of microchannel distillation sections. The number of microchannel distillation sections exchanging heat with each heat exchange channel zone may be in the range from 1 to about 100, and in one embodiment from 1 to about 10. In one embodiment, each microchannel distillation section exchanges heat with a separate heat exchange channel zone. The pressure within each heat exchange channel zone may be controlled using the foregoing passive structures, orifices and/or mechanisms. By controlling the pressure within each heat exchange channel zone, the temperature within each heat exchange channel zone can be controlled. A higher inlet pressure for each heat exchange fluid may be used where the passive structures, orifices and/or mechanisms let down the pressure to the desired heat exchange channel zone pressure. By controlling the temperature within each heat exchange channel zone, the temperature in the adjacent microchannel distillation section or sections can be controlled. Thus, for example, each microchannel distillation section may be operated at a desired temperature by employing a specific pressure in the heat exchange channel zone adjacent to the microchannel distillation section. This provides the advantage of precisely controlled temperatures for each microchannel distillation section. The use of precisely controlled temperatures for each microchannel distillation section provides the advantage of a tailored temperature profile and an overall reduction in the energy requirements for the distillation process. In one embodiment, this process may approach the energy requirements for a reversible distillation process.

[0104] The vapor phase and the liquid phase may contact each other in each microchannel distillation section (**370, 370***a*, **370***b*, **370***n***-2**, **370***n***-1**, **370***n*, **410, 410***a*) for a sufficient period of time to achieve at least about 25% by volume of the equilibrium composition for the fluid mixture being treated, and in one embodiment at least about 50% by volume, and in one embodiment at least about 70% by volume. The contact time for the contacting of the vapor and the liquid within each microchannel distillation section may be in the range from about 1 to about 200 milliseconds (ms), and in one embodiment from about 1 to about 10 ms.

[0105] The microchannel distillation units (**300, 300**A, **300**B, **300**C, **400**), microchannel condensers (**120, 120**B, **500**) and microchannel reboilers (**130, 130**B, **600, 700**) may be made of any material that provides sufficient strength, dimensional stability and heat transfer characteristics to permit the operation of the inventive process. These materials include: steel (e.g., stainless steel, carbon steel, and the like); monel; inconel; aluminum; titanium; nickel; platinum; rhodium; copper; chromium; brass; alloys of any of the foregoing metals; polymers (e.g., thermoset resins); ceramics; glass; composites comprising one or more polymers (e.g., thermoset resins) and fiberglass; quartz; silicon; silicon carbide; boron carbide; metal carbides such as aluminum carbide; silicon nitride; boron nitride; metal nitrides such as aluminum nitride; or a combination of two or more thereof. The microchannel distillation units may be fabricated using known techniques including wire electrodischarge machining, conventional machining, laser cutting, photochemical machining, electrochemical machining, molding, water jet, stamping, etching (for example, chemical, photochemical or plasma etching) and combinations thereof. The microchannel distillation units may be constructed by forming sheets or layers of material with portions removed that allow flow passage. A stack of sheets may be assembled via diffusion bonding, laser welding, diffusion brazing, and similar methods to form an integrated device. The microchannel distillation units may be assembled using a combination of sheets or laminae and partial sheets or strips. In this method, the channels or void areas may be formed by assembling strips or partial sheets to reduce the amount of material required. The assembly method may include the addition of wicking structures held adjacent to the liquid channel walls. The microchannel distillation units have appropriate manifolds, valves, conduit lines, etc. to control the flow of process fluids and heat exchange fluids. These are not shown in the drawings, but can be provided by those skilled in the art.

[0106] The inventive process may be used to separate any two or more fluids that have different volatilities. The process is particularly suitable for handling difficult separations such as ethane from ethylene wherein the fluids being separated have very similar volatilities. Examples of the separations that can be advantageously effected using the inventive process include, in addition to ethane from ethylene, styrene from ethylbenzene separation and associated purification of styrene monomer in an ethylbenzene dehydrogenation plant, separation of oxygen from nitrogen in the cryogenic towers of an air separation plant, separation of cyclohexane from cyclohexanol/cyclohexanone in a nylon monomers plant, deisobutanizers in a gasoline alkylation plant, naphtha splitters upstream from a naphtha reforming plant, and the like.

[0107] In one embodiment, the inventive process may be operated at a higher pressure and with more microchannel distillation sections (**370, 370***a*, **370***b*, **370***n***-2**, **370***n***-1**, **370***n*, **410, 410***a*) than conventional processes not employing microchannel distillation sections. With higher pressures and more microchannel distillation sections, the inventive process can be operated using higher temperature heat exchange fluids as compared to conventional processes. This reduces the amount of cryogenic heat exchange fluid required for many separations. For example, for the separation of ethane from ethylene, conventional processes operating at pressures of about 10 to about 25 atmospheres employ heat exchange fluids at temperatures as low as about −150° C., while with the inventive process operating at higher pressures, for example guage pressures in the range of about 30 to about 100 atmospheres, and in one embodiment about 50 to about 100 atmospheres, heat exchange